CHAPTER 7

REAL-TIME MANAGEMENT OF WATER CONTROL PROJECTS

7-1. Basic Considerations

a. Integration of Generalized Operating Criteria, Real-Time System Analysis, and Project Scheduling

(1) The discussions contained in Chapter 3 deal with the methods used in developing project regulation schedules and operating criteria for project or system regulation as documented in the water control manual. These criteria represent the commitment to an assured plan of regulation based on project justification and all constraints to meet water management goals.

(2) During daily water control management activities, special situations or unanticipated conditions may arise. This requires that a certain degree of flexibility be maintained to depart from normal operating criteria, if necessary. However, any decision to depart from specified criteria must be approved by the Division Commander and be based on a thorough knowledge of current conditions and management goals as specified in ER 1110-2-240. Unusual occurrences such as the spill of pollutants into the waterways may require immediate action that may depart from normal project operation. For example, toxic spills into projects with water supply require immediate response on the part of water managers, including prediction of dilution rates, and time of travel. Such an event will require extensive, complicated coordination and quick development of alternative operating strategies. Similarly, there may be unanticipated changed requirements that involve the safety or use of navigation facilities and waterways, such as ship groundings, shoaling of waterways or docking facilities, or special water requirements for managing terminal or ship repair facilities; the rescue of persons in the waterway whose lives are threatened; or other circumstances which require immediate action for the safety and well being of the general public. In addition to the problems related to normal functional use of the projects, a water management office is often requested to perform a variety of miscellaneous regulations for special purposes, such as maintaining water levels on a short-term basis for construction activities in the downstream waterway, maintaining flows for rafting, white water canoeing or river drifting, or regulating reservoir levels for improvement of wildlife habitat.

(3) All of the above conditions require judgmental decisions by the water control manager to adapt the operating guides to real-time

management. The water control manager relies on information provided by the water control data system, for making decisions that are necessary for daily scheduling. The majority of these decisions do not have far-reaching effects on project regulation, and the decisions are approved as part of normal water management activities. However, some decisions may represent a significant departure from the water control plan or may create adverse impacts on future project regulation activities. If such is the case, recommendations for a particular operation will be referred to higher echelons for written approval as part of the decision making process.

b. Input from Others. The management of nearly all river systems now involves multiagency or multipurpose input. Even though some Corps of Engineers reservoirs may have been constructed initially as single purpose, single agency projects, the changed conditions that reflect the recently added environmental and social impacts of projects have brought a variety of federal, state, and local entities into the water management process. While these agencies or entities do not have responsibility for control and management of Corps of Engineers projects, they do provide significant input, which reflect their technical evaluations and desired regulation goals. Input from these agencies also include current basic data that pertain to project operation and are necessary for system-wide evaluations. These agencies include:

- federal and state environmental control and fishery management agencies

- international, federal and state water resource development or regulatory agencies whose projects or jurisdictions affect the operation of Corps of Engineers projects

- international, federal, regional or state energy authorities, administrations, councils, or commissions

- private utilities or local water boards whose projects or jurisdiction may have impacts on the regulation of Corps projects

Other types of inputs also include current hydrologic data made available from other federal or state water data gathering agencies. These include:

- streamflow, water quality, or water level data from the U.S. Geological Survey or other agency

- current weather data, and weather forecasts and certain hydrometeorological data from the National Weather Service

- snow water equivalent data and related hydrometeorological data from the U.S. Soil Conservation Service

- state or local water agency hydrometeorological and water use data covering state or local water projects

Data from any or all of the above listed agencies or entities may be necessary as input to Corps water regulation activities and would be used or considered in scheduling project regulation. Chapter 8 discusses the methods for coordinating interagency water management activities in greater detail.

7-2. Appraisal of Current Project Regulation. Monitoring system regulation and scheduling future project regulation go hand-in-hand. The objective of monitoring project regulation is to verify that the current operation is proceeding according to the daily regulation schedules and in conformance with the regulation plan as defined by the guide curves and other regulation criteria. Each day the water control manager must appraise the current regulation by comparing actual and guide curve reservoir levels, together with the system demands for each of the functional uses. These comparisons provide the basis for analyzing regulation schedules to meet the future requirements of system regulation in concert with the operating guide curves. The guidelines for scheduling project regulation may be based on the conditions of streamflows and water levels either at downstream control points or at the project, as necessary to meet system demands. For a system of reservoirs operated together, the relative use of storage space for functional needs is defined by the operating guide curves. These guide curves must be analyzed on a daily basis together with the hydrologic and reservoir system conditions to meet the overall objectives.

7-3. Performing System Analyses for Project Scheduling

a. Analytical Requirements for Scheduling Water Regulation at Projects. The daily appraisal of current project regulation provides the water control manager with a general understanding of the hydrologic and project conditions that will affect the scheduling of water regulation in the immediate future. After evaluating current conditions, the water control manager may next consider the input from others which affect project schedules; e.g., immediate needs for hydropower generation, water supply, or other multipurpose functional requirements. The water control manager will also obtain a general review of the current meteorological conditions and the latest forecasts of weather elements that will affect project regulation.

Some of the information thus obtained is quantitative in nature, but not all is susceptible to quantitative definition. To some degree, it would be possible on the basis of subjective evaluations to schedule project regulation without rigorous analysis of the operating conditions. Usually, however, the complexity of the systems and the many variables that must be considered quantitatively preclude the use of simplified procedures or subjective estimates for scheduling the regulation of major water control systems. Computerized analytical procedures that are now available make it feasible to perform analyses of the reservoir and water control systems on a daily basis. These procedures are objective and can account for the effects of each of the major hydrologic and project regulation elements in order to analyze the system response to various alternative project schedules or hydrologic conditions.

b. Preparing Model Input Data

(1) A generalized hydrologic and reservoir regulation simulation model requires various input data:

(a) nonvariable data, which describe physical features such as drainage areas, watershed runoff characteristics for each component watershed, channel routing characteristics, reservoir storage and flow characteristics, and other physical parameters which define the system;

(b) initial conditions data for specifying current conditions of all watershed indexes, incremental flow routing values for watersheds and channels, and current reservoir lake elevations and outflows;

(c) time-variable data expressed as a time-series for representing hydrometeorological inputs and forecasts such as precipitation, air temperature, snowmelt and evapotranspiration functions, streamflow data, project regulation data, or other time-variable elements that affect runoff, project regulation and system requirements;

(2) The project regulation criteria for each run must also be specified, which will conform to the general project regulation criteria contained in the water control plan. Special requirements for water regulation (for example, needs expressed through inputs from other entities) may be included in the specifications to test the feasibility of meeting those needs in conjunction with the water control plan. The water control manager prepares the specific regulation criteria for each run from knowledge of conditions as they exist and the normal or special regulation requirements.

c. Analysis of Results

(1) As stated earlier, the main purpose of real-time system analysis studies is to provide the water control manager with the ability to simulate the proposed regulation and thereby anticipate the effects of operating decisions on future regulation. The simulations are based on the most complete knowledge of present and future conditions in order to analyze the effects on a short- and medium-range time frame, to test the effects of various alternatives of regulation and expected weather conditions, and thereby to provide an objective and rational basis for making operating decisions and scheduling project regulation. Thus, the water control manager is in constant touch with the actual current regulation and the projections of the regulation into the future. The computer system analysis techniques that are designed for this purpose can be operated interactively so that computed results are available in a very short period.

(2) This concept of real-time system analysis provides the opportunity to make repetitive trials of system regulation when conditions warrant it. By performing these analyses routinely, the water control managers become completely familiar with the use of these techniques, so that when emergency conditions arise, they are able to make full use of these capabilities in a timely and efficient manner.

7-4. Water Control Decisions and Project Scheduling

a. Need for Judgmental Determinations in Project Scheduling

(1) Even with the numerical analysis described in the preceding section, the final decisions in formulating project schedules may require the tempering of derived analytical values by the judgment and experience of the water control manager. The water control plans provide the general guidance for project regulation, but they cannot describe the myriad of details that must be accounted for in daily regulation and project scheduling. Further, while the analytical procedures described in the previous section are an attempt to simulate the actual operation within the degree of the ability of the models to represent all processes, the results reflect uncertainties that may be evaluated subjectively.

(2) On a broader scale, judgments may be required to "shade" the operation when conditions indicate a particular need, as, for example, a mid-month adjustment in operating guide curves, which are specifically defined as month end values, and current analysis and projections indicate a probable change in conditions by month end.

The simulation of streamflows and project conditions provides for maintaining the continuity of the hydrologic processes and for providing an outlook of future conditions. These evaluations may form the basis for mid-month adjustments of guide curve operation. By being alert to changed runoff potentials as they occur, the overall efficiency of multipurpose project regulation may be significantly improved. It should be emphasized that modifications of the guide curve operation must be based on rational evaluation of runoff conditions that warrant such departures. When such modifications are made, the water control manager must be constantly alert to changed conditions that would require return to normal guide curve operation.

b. Coordinating Water Control Decisions with Others. Corps offices have the responsibility for managing projects under their jurisdiction. This responsibility is delegated to the working level through the water management functional elements within the operating office. The management of nearly all river systems now involves multiagency or multipurpose input. This input, which is usually obtained through direct communication between the requesting agency and the scheduling office, must be considered in formulating the project schedules. Some of the input is coordinated as provided for in various types of water control management agreements and plans, including:

- interagency water control management agreements with power marketing authorities, fish and wildlife agencies, etc.

- electrical utility coordinated power operating plans and contractual agreements

- water control plans for non-Corps projects which involve flood control or navigation requirements

- water control plans for water regulation projects developed under international treaties

- water compacts with state, regional, or local agencies or councils

There are other types of input from agencies or entities outside of the Corps of Engineers that is not based on formal operating procedures, but through voluntary informal arrangements. The many types of inputs covered by these operating arrangements and agreements has widely varying significance to scheduling the use of water on a daily basis, but all must be coordinated in a manner to meet the water management goals. Routine requests as called for in the agreed-upon operating plans are normally handled by the water

control manager, and minor adjustments may be made to achieve optimum system regulation. If, however, a scheduling problem is encountered involving a question of policy that would significantly affect the planned use of the reservoir storage, the question will be referred to the water control manager for recommendations and action. The final decision will require approval by the Division Engineer.

c. Project Schedules and Operating Instructions

(1) The monitoring, coordinating, scheduling and evaluation of project regulation are normally performed on a daily basis, and the schedules usually represent an operating commitment for the ensuing 24-hour period. Although the projections of project regulation may provide longer-range outlooks, these outlooks are normally subject to change on a daily basis. The schedules and operating instructions may be in various forms, including one or more of the following provisions:

- mean total project discharge in cubic feet per second, for a specified 24-hour period, or for specified amounts for individual period or hourly values (Under some operating agreements, the schedules are required to be made for weekly rather than daily periods if conditions allow.)

- specific gate opening

- target reservoir level as an end of daily or period value

- mean reservoir storage change of acre-feet per day or day-cfs

- specific operating constraints for the ensuing day, as, for example, maximum and/or minimum reservoir levels, maximum and/or minimum project discharges, rates of change of tailwater levels, etc.

- power plant generation as scheduled daily or hourly amounts

- special operating instructions not covered by the specified normal limits of project operation

- special operating instructions for multilevel intake structures

(2) It is required that all project regulation be accomplished within the operating constraints as specified in the project water control manuals. The constraints apply to conditions both at the project and at downstream locations, and they may vary seasonally or may apply to specific requirements that depend upon the conditions of

tributary flow, fishing, or other downstream water use functions. The water control manager is responsible for seeing that the water regulation is performed within all operating constraints and that the daily project schedules and operating instructions are properly carried out.

(3) In times of flood or other types of emergencies, the project schedules must be revised as required to meet the flood regulation goals. This may require 24-hour staffing during flood emergencies when considerable effort is needed to keep abreast of conditions and to adjust the project schedules to reflect changed conditions. These problems are discussed further in Section 7-6.

(4) In times of drought, contingency plans will be needed to assure that all flow requirements are met and reduction in releases are made as appropriate. Their may be special local water supply requirements during drought situations that are not part of normal water control management activities. Drought contingency plans are discussed in Section 7-7.

d. Water Quality Aspects of Water Control Decisions. The water quality aspects of project regulation requires a constant awareness of the fact that every regulation decision has an impact on the water quality of the lake and the area of influence downstream. To evaluate the impact of any operating decision requires input from as broad a range of relevant disciplines as possible. With this input the water control manager can make the best choice and derive the most benefit from the project and the resources he controls.

7-5. Disseminating Regulation Schedules

a. Corps of Engineers Projects. Daily schedules and operating instructions must be transmitted from the water management office (Reservoir/Water Control Center, Reservoir Regulation Section, etc.) to each project office in a timely manner. The communication to Corps of Engineers projects may be by telephone, teletype, or other electronic means. For large reservoir systems, where project operation is integrated, it is desirable for each project to receive the schedules for all other projects in that river system. The information allows the project operators to be aware of scheduled operations for upstream projects that may affect their project operation. It also provides the project operators with a more complete understanding of the total system regulation. The projects may also receive the forecasts and outlooks of future project regulation that are obtained from current system studies as described in Section 7-3.

b. Non-Corps Projects. Disseminating flood control and navigation water regulation schedules to non-Corps projects is usually accomplished through the operating office of the project owner. In some cases, however, the operating instructions are transmitted directly to the project, in accordance with operating agreements with the agency or utility. Although the general criteria for scheduling the regulation of non-Corps projects is in accordance with the procedures described herein for Corps projects, the means of scheduling the regulation varies among projects and operating entities. For some projects, all aspects of scheduling are performed by the operating office of the project owner, and the Corps water management office monitors the operation to insure that the project is operated in accordance with agreed-upon project regulation criteria. For non-Corps projects that are integrated into Corps-wide flood control or navigation systems, operating schedules are prepared and dispatched directly by the Corps office.

c. Distributing Schedules to Other Agencies. There are other agencies or entities, which are not project owners or operators, that have a need to know daily water regulation schedules. These agencies include power marketing authorities, streamflow forecasting entities, and fish and wildlife or environmental protection agencies. The schedules are transmitted to them each day to confirm the specific water regulation for the ensuing 24-hour period. Automated water data systems, as described in Chapter 5, may be used for distributing schedules to these agencies. These schedules may be distributed via computer terminal or teletype or telephone for systems that lack a comprehensive automated water data network.

d. Distributing Schedules to General Public. Normally, the daily regulation schedules are considered to be internal working directives that are distributed to agencies or entities directly involved in the water management or streamflow forecasting activities within the river system. Under some circumstances, the general public needs the information contained in the operating schedules. Recreationists that use the river for fishing, boating, drifting, or other activities; navigation, and agricultural or urban riparian interests, who are affected by the regulation of streamflows and river levels, all may need information contained in the operating schedules.

7-6. Water Management Activities During Flood Events

a. Importance of Water Management Activities. Up to now the discussions of scheduling daily regulation have been directed mainly to routine operating conditions based on a cycle of normal daytime operations of the Reservoir/Water Control Center or other water

management element. The intensity of water management activity increases significantly during times of flooding, which may require that the water management office and affected projects be staffed 24 hours per day, including weekends or holidays. Water control managers must closely monitor rapidly changing hydrologic conditions and be prepared to re-evaluate runoff conditions since they may affect project schedules and river conditions at downstream locations. Under rare circumstances, floods may result from dam breaks, earthquakes, landslides, or volcanic eruptions, which may cause serious and unexpected life threatening flood disasters. While this type of occurrence cannot be forecast in advance, such disasters require immediate action when they do occur. Under the more normal types of floods occurring as the result of rain or snowmelt runoff, there is need for frequent direct communication between the water control management element and project operators as the floods progress to obtain the most recent information of conditions at the project that may relate to project regulation. This direct communication is also needed to keep the projects abreast of the most current assessments of schedules and precautions that may affect current operations. The water management office must respond to requirements for issuing flood reports to higher authority and keep other elements of the office fully informed of operational conditions that may affect other Corps activities (e.g., flood fighting, disaster emergency operations, coordination with federal, state and local authorities, and public relations). Under extremely critical floods, the entire effort of Corps installations within the region may be diverted to the activities associated with the flood. This often includes the major basic functional Division or District office elements of engineering, operations, construction, planning, procurement, personnel, and public affairs, as well as other supporting elements. These activities must be directed and coordinated by top level management, and because of the relatively sudden change of activities during flood events, the office must be prepared to adjust its normal activities to a concerted effort required during emergency conditions.

b. Coordination of Corps Activities

(1) Because of the changed direction of activities involving the various elements of the Corps offices during flood events, there is a need for coordination and centralized direction of flood related activities. One of the important aspects of the required coordination is to provide authoritative and timely information regarding the flood. The various elements of Corps offices must be fully informed of current conditions. Therefore, it becomes extremely important that the water management office, as the focal point of water control management activities, be prepared to provide all of the latest information pertinent to the flood conditions,

including:

- a general summary of current weather and hydrologic conditions, their effects on runoff, and areas of flooding

- forecasts of weather conditions, with particular emphasis on the outlook for flood producing potentials

- forecasts of natural and regulated streamflows at the projects and at key downstream locations

- the current status of water control facilities as related to project and system wide management of water for all project purposes, with special emphasis on the effects of regulation on the control of floods throughout the system

- the expected water levels at all key downstream locations, with special emphasis on those areas protected by levees or other control structures

- the planned use of storage space, interior drainage facilities, by-pass and diversion structures for the duration of the flood

- the planned use of non-Corps projects (including international projects) for current flood regulation and the coordination required to achieve the flood regulation goals

- the coordination of flood regulation in the management of multipurpose water control projects with other interests such as public and private utilities, power marketing authorities, fish and game agencies, and state or local water agencies

- description of any special conditions related to weather and river conditions that might affect water regulation and Corps of Engineers activities being undertaken as the result of the flood

(2) Because of the expanded role of the water management office during floods, the resources of that office are fully devoted to meeting its responsibilities for analyzing the system, scheduling and coordinating project regulation, and maintaining continuity of data systems and displays. The briefing room facilities available for normal river and reservoir briefings provide all of the necessary data and information systems required for informational summaries described in the preceding paragraph. Therefore, it is generally highly desirable that these facilities be utilized in an Emergency Operation Center through which the District or Division office

commander may direct the flood activities.

c. Monitoring and Reanalyzing River and Reservoir Conditions During Floods. The principles and methods of real-time system analysis for normal scheduling operations are also applied during major floods, but with special emphasis on keeping abreast of current hydrologic conditions. Because of the importance of maintaining continuity of the rapidly changing events during floods, the efforts on analysis are intensified. During major floods, monitoring the hydrologic events throughout the river system and assessing the latest weather forecasts that affect meteorological inputs are all important in reanalyzing these conditions. When computer simulations are used for analyzing system runoff and projecting reservoir regulation, the continuity of forecasted and observed conditions are compared frequently (perhaps hourly or on a 3- to 6-hour basis), and judgments are made to determine the need for reanalysis of system operation. Thus, the results are being constantly reanalyzed and updated during floods, in order to schedule project regulation most effectively.

d. Adjusting Reservoir Regulation Schedules. As a result of the monitoring and reanalysis of conditions it may be necessary to adjust project schedules on a frequent basis. The needs are determined from the knowledge and experience of the water control manager.

7-7. Drought Management Plans

a. ER 1110-2-1941, Drought Contingency Plans, requires that a drought management plan be developed and implemented as part of overall water control management responsibilities. All Corps projects having controlled storage must have documented drought management procedures. The Water Control Manual for each project will contain a section on special procedures to be followed during droughts. In addition, basin-wide drought management plans should be incorporated into Master Water Control Manuals.

b. When developing a drought management plan, alternate strategies for project or basin-wide operating criteria should be formulated based on the longevity and severity of potential drought events. The following approach should be taken when formulating strategies for project regulation during droughts.

(1) Select critical low flow sequences from historical flow records for detailed analysis.

(2) Develop priorities of water needs considering the

anticipated impact of the drought on activities and resources of the basin. Consider how priorities may change under worsening conditions.

(3) Make computer drought simulations and evaluate alternative water management operating scenarios based on selected historical low flow sequences and the established water need priorities. When reduction of releases are being contemplated, both lake and downstream users should be considered. Results of drought simulations and evaluations should include reservoir inflow, outflow, area, storage, elevation, and water quality parameters.

(4) Make an assessment of the impacts of alternative operating scenarios on basin resources and activities.

(5) Develop tentative basin strategies based on the impact assessment and coordinate these strategies with appropriate local, State, and Federal agencies and other appropriate interests prior to adoption.

c. A coordination plan should be developed for making decisions and implementing actions to be taken during drought situations. The plan should include a public information program and the establishment of a drought advisory committee comprised of representatives from involved agencies. Interests that mat be impacted by drought operations should be documented in the coordination plan.

d. After a drought management plan has been developed based on existing constraints, long-term opportunities to modify projects based on changes in basin development and water supply needs should be assessed. This may be accomplished by a reconnaissance study for evaluating the feasibility of alternative actions if current operating constraints are removed or modified. Examples of potential modifications include changes in project operation guide curves, minimum flow requirements, and storage allocations.

7-8. Coordinating Forecasts of Streamflow and River Levels

a. General

(1) The river and reservoir system simulation analyses, described in Section 7-3, are the principal technical evaluations used for management of water control systems and scheduling project operation. For those rivers that are controlled by reservoir storage and managed in accordance with the principles outlined in this manual, the streamflow synthesis and reservoir regulation computer

runs constitute the primary source of data on which to base not only the scheduling and control of project operation, but also the forecasts of river conditions in the system as a whole. These computer runs simulate both natural and man caused effects. Therefore, they express the most recent determinations of hydrologic analysis and project schedules by those persons who have the specific knowledge of the hydrologic conditions. Inasmuch as these persons in the water management offices have direct operational control and management of the river systems in which they operate, their operating decisions have primary influence on water conditions in the system, and the hydrologic and river system forecasts for scheduling reservoir operations become the basis for general streamflow and river level forecasts.

(2) Federal and state agencies other than the Corps of Engineers who are also involved in streamflow and river level forecasts must necessarily base their forecasts on assumed or hypothetical effects of project regulation, as well as forecasted conditions of hydrometeorological variables. Water management and river forecasting agencies should coordinate their activities so that the water management decisions and river forecasting data can be based on common information. The exchange of hydrologic and operational data is the first step in coordinating among the offices. A primary goal is to obtain a coordinated forecast which utilizes the expertise of the agencies involved. The ability to achieve this goal depends upon the particular circumstances within each river basin area.

(3) It is important to emphasize that Corps water control management personnel must recognize and observe the legal responsibility of the National Weather Service (NWS) for issuing weather forecasts and flood warnings to the public as described in ER 1110-2-240. Corps water control managers often need to make additional forecasts of stream flows and river levels to best meet multipurpose project water control objectives. Corps forecasts should not be released to the general public unless done through the NWS. Duplication of effort among forecasting agencies should be avoided and forecasts coordinated and shared to the greatest extent possible.

b. Basin-Wide Forecasting Services

(1) An example of a joint operation for basin-wide forecasting of a river system, in conjunction with requirements for project operation and the preparation of river forecasts for the general public, is the Columbia River Forecasting Service. In 1963, the Cooperative Columbia River Forecasting Unit was established by formal agreement between the Chief of Engineers and the Chief of the Weather

Bureau (now the National Weather Service). Under this agreement, forecasting facilities of the North Pacific Division Office of the Corps of Engineers and the Portland River Forecast Center of the National Weather Service (now the Northwest River Forecast Center) are utilized jointly to develop more reliable and timely forecasts of streamflow at key locations. In 1971 the agreement was rewritten, and the Bonneville Power Administration became a party to the agreement 18/. The coordinated forecasting unit was also renamed and is now titled the Columbia River Forecasting Service (CRFS).

(2) A technical committee, which is composed of representatives of each of the three participating agencies, directs the activities of the CRFS. Each of the agencies supports these activities with equipment, facilities, data handling procedures, computer hardware and software, and manpower as required for system development and operational use. The technical committee meets periodically to discuss methods relating to CRFS objectives. More detailed information pertaining to interagency coordination of water management activities is presented in Chapter 8.

(3) Within the Corps of Engineers there are other ongoing cooperative efforts of varying degrees for developing and implementing basin-wide river forecasts.

Figure 7-1. Garrison Dam, Missouri River, North Dakota; Omaha District